

Validation of GPS Data-Driven Ionospheric Specification Models

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Abstract

Dual-frequency transmissions from the Global Positioning System satellites have been used for many years to measure and map ionospheric total electron content (TEC) on global scales. JPL's Global Ionospheric Mapping (GIM) software uses observations from ~100 GPS sites, an extended "shell" model, and Kalman filtering to compute global maps of vertical TEC with 15-minute time resolution and ~5-degree spatial resolution. Recently, the GIM algorithms have been enhanced to solve for multiple parameters on a shell grid, instead of just the single value of vertical TEC. Such multi-parameter models are designed to improve the accuracy of slant TEC retrievals and the ability to calibrate slant TEC delays for arbitrary raypaths. The extra parameters allow GIM to better model horizontal gradients and variations in peak height, while still retaining a simple, constrained fitting model as compared to a full tomographic density solution which is vastly underdetermined.

A fully 3-dimensional Global Assimilative Ionosphere Model (GAIM) is currently being developed by a joint University of Southern California and JPL team. GAIM uses a first-principles ionospheric physics model ("forward" model) and Kalman filtering and 3DVAR techniques to solve for densities on a 3D grid. Although GAIM will ultimately use multiple datatypes and many data sources, one can perform a first test of quantitative accuracy by ingesting GPS-derived TEC observations and then comparing the accuracy of the retrieval to a corresponding run of the enhanced GIM model. A series of such GAIM versus GIM comparisons will be presented and the accuracy of both retrievals will be validated by comparisons to several kinds of independent ionospheric observations: vertical TEC data from the TOPEX altimeter, slant TEC data from GPS sites that were not included in the assimilation runs, and global ionosonde data (F0F2, HMF2, and bottom-side profiles where available). By presenting animated movies of the GAIM densities and TEC maps, and their errors computed as differences from the independent observations, we will characterize the reasonableness and physicality of the climatology derived from the GAIM forward model and the quantitative accuracy of the ionospheric "weather" specification provided by the assimilation retrievals.